TMA PAYLOAD, FIELD SERVICES AND DATA REDUCTION - HAES NUMBER 17

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GCA Corporation

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Final Report for Period 9 November 1973 - 15 December 1974

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Upper atmospheric winds were measured during the night of 18 February 1974 from observations of a trail of TMA released from a Nike-Hydac over the Poker Flat range near Fairbanks, Alaska. Ground based photographic sites were used to record the observational data and triangulation methods were employed in data reduction. The wind profiles from that trail and from another similar trail during the night of 27 March 1973 are reported.

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PREFACE

The High Altitude Effects Simulation (HAES) Program sponsored by the Defense Nuclear Agency since the early 1970 time period, comprises several groupings of separate, but interrelated technical activities, e.g., ICECAP (Infrared Chemistry Experiments - Coordinated Auroral Program). Each of the latter have the common objective of providing information ascertained as essential for the development and validation of predictive computer codes designed for use with high priority DoD radar, communications, and optical defensive systems.

Since the inception of the HAES Program, significant achievements and results have been described in reports published by DNA, participating service laboratories, and supportive organizations. In order to provide greater visibility for such information and enhance its timely applications, significant reports published since early calendar 1974 shall be identified with an assigned HAES serial number and the appropriate activity acronym (e.g., ICECAP) as part of the report title. A complete and current bibliography of all HAES reports issued prior to and subsequent to HAES Report No. 1, dated 5 February 1974 entitled, "Rocket Launch of an SWIR Spectrometer into an Aurora (ICECAP 72)," AFCRL Environmental Research Paper No. 466, is maintained and available on request from DASIAC, DoD Nuclear Information and Analysis Center, 816 State Street, Santa Barbara, California 93102, Telephone (805) 965-0551.

This report, which is the final report under AFCRL contract No. F19628-74-C-0084, covers the technical activities during the period 9 November 1973 through 15 December 1974. The activities during the period 28 November 1972 through 23 May 1973 are contained in the final report on Contract No. F19628-73-C-0087, entitled "TMA Winds Program." References to previous and related programs are contained in these reports. The direct objective of this program was to measure the vertical profile of the thermospheric winds during the period in which observations were being made by other rocket-borne instruments and by various ground based systems. The purpose of the measurements were to investigate the dynamics of the polar thermosphere; to provide detailed wind measurements during the coordinated measurement program; to furnish an opportunity for comparison of results from various measuring systems: and to assist in the evaluation of results and future planning.

It is appropriate to note that a major innovation in the measuring technique was developed during the period covered by the referenced reports. Although, the development resulted primarily from other programs the impact on future HAES programs may be substantial. The direct measurement of winds in the ICECAP Programs have been restricted to nighttime and twilight because the method could not be used during the day. In addition, the requirement for "good observing" conditions for ground sites, which usually posed severe logistic problems, caused costly delays in the program. The new development in which all observations are performed from a high flying aircraft

eliminates the weather restrictions and allows measurements in the daytime. Thus wind measurements for HAES programs need not cause delays and can be scheduled to coincide with special conditions or events at all times including the day. This report includes the application of part of the new technique in the data from the chemical release of 26 March 1973, which was obtained from a single site observation by means of a modification to the airborne data reduction procedure.

The authors wish to acknowledge the contributions of A. C. Faire of the Aeronomy Laboratory, AFCRL in this program. The support and participation of all facilities associated with the Poker Flat Range and the University of Alaska Geophysical Institutes are gratefully acknowledged.

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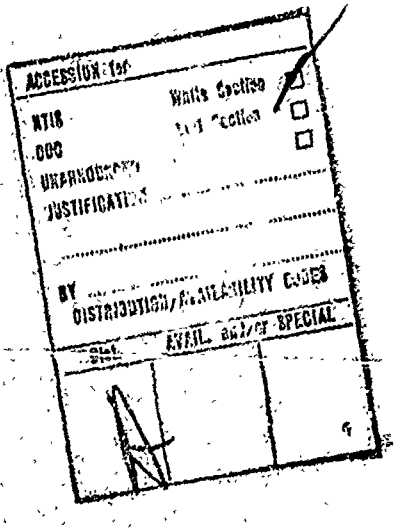

SECTION I

INTRODUCTION

The general objective of this contract was the measurement of thermospheric winds during a coordinated program involving several sounding rocket launches and associated ground based observations at Poker Flat, Alaska. The wind measurements were to be obtained from ground based photographic observations of a trail of trimethyl-aluminum (TMA) released from a sounding rocket. The specific tasks included modification of the design of a standard TMA payload so that it could be effectively utilized with a Nike-Hydac rocket system; construction of the payload, providing field services to assist during the payload preparation and rocket launching, providing camera equipment and personnel for supervising the camera operation, and reduction of data.

The rocket was launched successfully from the Poker Flat range at 2143 AST on February 18, 1974. The rocket payload is briefly discussed in Section II. The photographic sites and observations during the rocket launch are described in Section III. The data are reported in Section IV. Section V contains the wind data obtained from a previous trail released at about local midnight of March 26-27, 1973. The details of the launch and observations of that trail are reported in the Final Report on Contract No. F19628-73-C-0087. The reduction of that data was funded by this contract.

SECTION II

TMA PAYLOAD

TMA interacts with the atmosphere to produce a chemiluminescent glow which usually allows wind observations at night over the height range 90 to 140 ± 10 km. A standard payload to produce a trail from a smaller rocket system (Nike-Apache) has been used successfully for a number of years. Minor modifications to this design which allow its efficient use with the Nike-Hydac system are much less expensive than a new design and eliminate the necessity for extensive performance tests because of the successful past flight record of the unit. These units contain two completely independent actuator systems composed of a preset mechanical timer, batteries, pressure switch, arming plugs, and electrically actuated valves. Payloads have been delivered on previous contracts and were described in detail in a report entitled "Alkali Vapor Payload Assembly and Checkout Manual" GCA-TM-69-1, Contract No. F19650-69-C-0509.

The minor modifications required to adjust the standard unit for utilization on a Hydac vehicle are fitting the TMA cannister and instrument rack into a 9 inch O.D. cylinder with the proper forward and rear interface connections. The connections are standard designs with complete drawings and specifications. The sections were machined according to these drawings and then checked before shipment by actual fitting to the other rocket sections.

The use of the standard units also allowed the use of the standard procedures for preflight checks, final assembly, and pad checks.

SECTION III

PHOTOGRAPHIC SITES AND OBSERVATIONS

The geographical locations of the three camera sites which were established for the observation of the February trail are listed in Table 1.

TABLE 1

LOCATION OF PHOTOGRAPHIC SITES

Name	Latitude North	Longitude West
Fort Yukon	66° 33.0'	145° 13.0'
Ester Dome	64° 53.0'	148° 3.2'
Fort Greely	63° 56.4'	145° 48.0'

All of these sites had heated enclosures for the personnel and equipment and clear plexiglass bubbles through which the vapor trail could be photographed. Phone line communications to the sites were reliable, however Fort Yukon can only be reached by air. The other two sites are usually accessible by road.

All of the sites were supplied with two 70mm cameras having a 3.3" lens which operated automatically from a synchronous timer. The operator actuates the unit at a precise time in order to ensure simultaneity of photographs at all sites. Each site also was supplied a K-24 camera having a 7" lens and a similar but separate timer for automatic operation.

GCA personnel aided in establishing the sites, furnished the cameras, instruction on camera operation and observational procedure, and operated the cameras at the Ester Dome site during the rocket launch. Camera operation, communication and logistics with the other sites were provided by the Poker Flat range.

Prior to the launch all sites were reported to be clear and operating normally. The vapor was released as scheduled and visually observed from all sites including the launch area. After the launching, the operator at Fort Yukon reported difficulty with the 70mm camera controls. Subsequent inspection of these controls by the GCA personnel detected no fault in the

equipment, however, no useful photographs were obtained from those cameras, although the K-24 camera at Fort Yukon did produce limited trail photographs. Good data were obtained at Ester Dome and Fort Greely. The wind profile from these observations is discussed in Section IV.

SECTION IV

ANALYSIS OF VAPOR TRAIL DATA FROM FLIGHT DN-7021

Flight DN-7021 was launched at 07 43 U.T. on 19 February 1974 from the Poker Flat Range and released a trail of TMA which was photographed from the Ester Dome and Fort Greely sites. A useful radar track of the rocket vehicle was obtained above 104 km. Standard triangulation methods were used to obtain the wind data that are tabulated in Table 2 and shown graphically in Figures 1, 2 and 3. It is anticipated that other experimenters will utilize these data for various purposes, so a special emphasis was placed on determining the accuracy or uncertainty in the reported wind speeds in Table 2. The uncertainty of the measurement is given in meters/sec under the heading E following the tabulation of both the eastward and northward components. Larger uncertainties occur primarily in regions of the trail which persisted for only a short time and in regions of high shear. The uncertainty figures were obtained from variations in results obtained from sequential triangulations utilizing the standard two site procedures as well as the single site method that was used in the data from Flight A10.216-3 and is discussed in Section V. It is noteworthy that the wind values and uncertainties obtained by the two methods were essentially the same. The ability to utilize one site can relax the stringent weather requirements that have caused long delays in vapor trail firings.

TABLE 2

WIND COMPONENTS FOR FLIGHT DN-7021 LAUNCHED POKER FLAT, ALASKA, 07 43 U.T., 19 FEBRUARY 1974. U IS EASTWARD COMPONENT; V IS NORTHWARD COMPONENT; E DENOTES UNCERTAINTY

H (km)	U (m/s)	E (m/s)	V (m/s)	E (m/s)	H (km)	U (m/s)	E (m/s)	V (m/s)	E (m/s)
132	22	2	-65	2	107.5	-48	1	-70	1
131	22	2	-61	2	107	-49	1	-78	2
130	21	2	-57	2	106.5	-52	1	-87	2
129	20	2	-53	2	106	-52	1	-97	2
128	19	2	-48	2	105.5	-48	1	-105	2
127	18	2	-42	2	105	-43	2	-112	1
126	17	2	-33	1	104.5	-38	2	-117	1
125	17	1	-24	2	104	-32	3	-119	1
124	17	1	-15	3	103.5	-15	5	-119	1
123	19	1	-4	1	103	3	2	-116	1
122	23	2	6	3	102.5	16	2	-111	2
121	31	2	18	2	102	28	3	-105	2
120	39	3	28	2	101.5	41	5	-101	1
119	46	1	35	1	101	52	4	-96	2
118	49	1	38	1	100.5	59	4	-91	2
117.5	45	1	39	1	100	74	4	-83	3
117	40	1	37	1	99.5	96	5	-74	3
116.5	36	1	35	1	99	121	7	-50	6
116	32	1	33	1	98.5	122	7	-45	6
115.5	26	1	30	1	98	120	7	-40	7
115	22	1	27	1	97.5	118	7	-34	7
114.5	14	3	24	1	97	116	7	-23	5
114	6	3	20	1	96.5	113	7	-9	7
113.5	-1	3	16	1	96	108	10	15	10
113	-13	3	11	1	95.5	104	7	35	10
112.5	-23	1	5	1	95	97	7	68	7
112	-32	3	0	3	94.5	92	5	73	7
111.5	-39	3	-6	2	94	89	4	67	10
111	-45	1	-12	1	93.5	88	4	58	5
110.5	-46	1	-18	1	93	87	4	50	10
110	-47	1	-25	2	92.5	87	4	30	10
109.5	-48	1	-43	2	92	88	4	20	5
108.5	-47	1	-54	1	91.5	91	5	18	5
108	-48	1	-63	1					

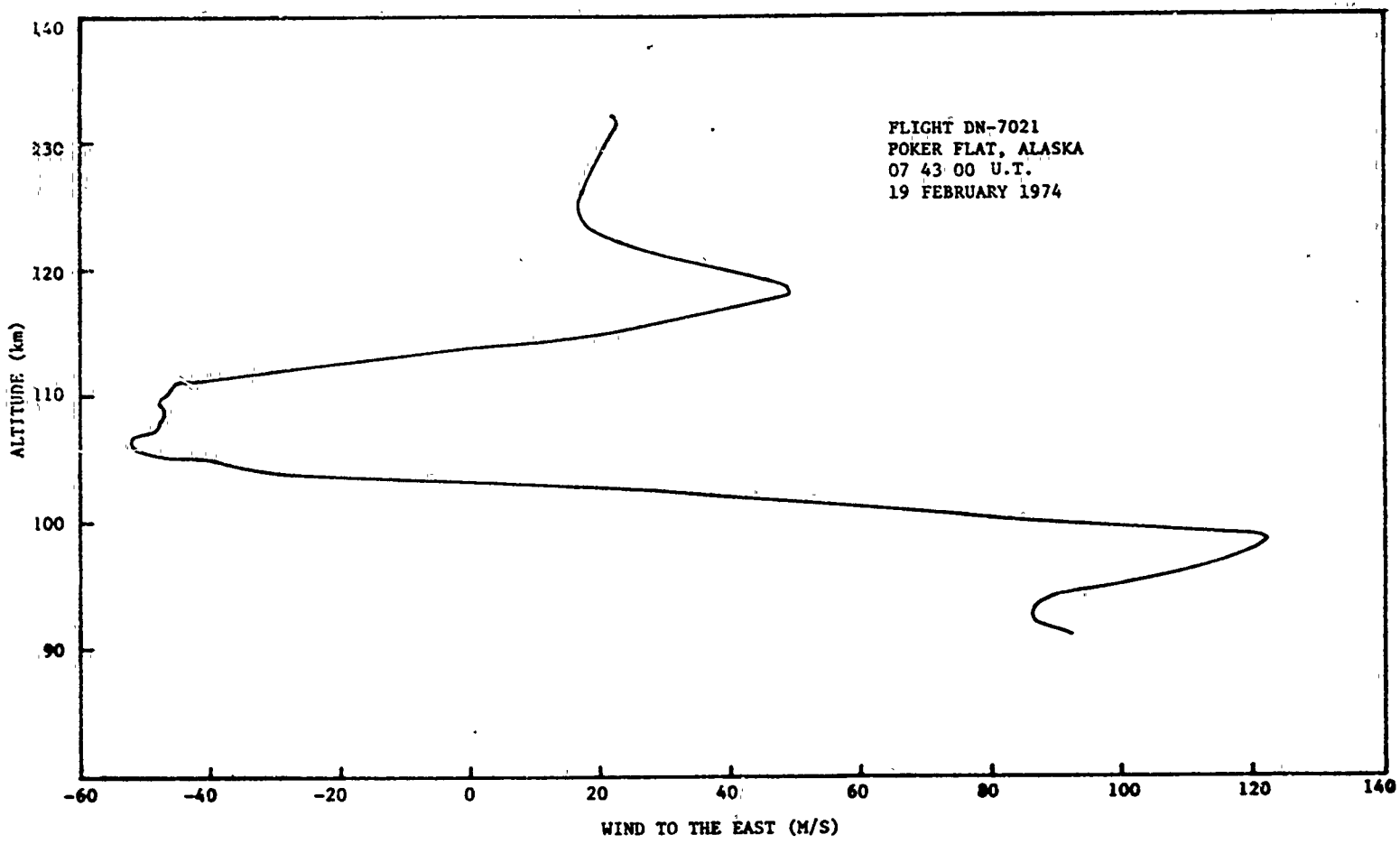

Figure 1. Eastward component of winds for flight DN-7021.

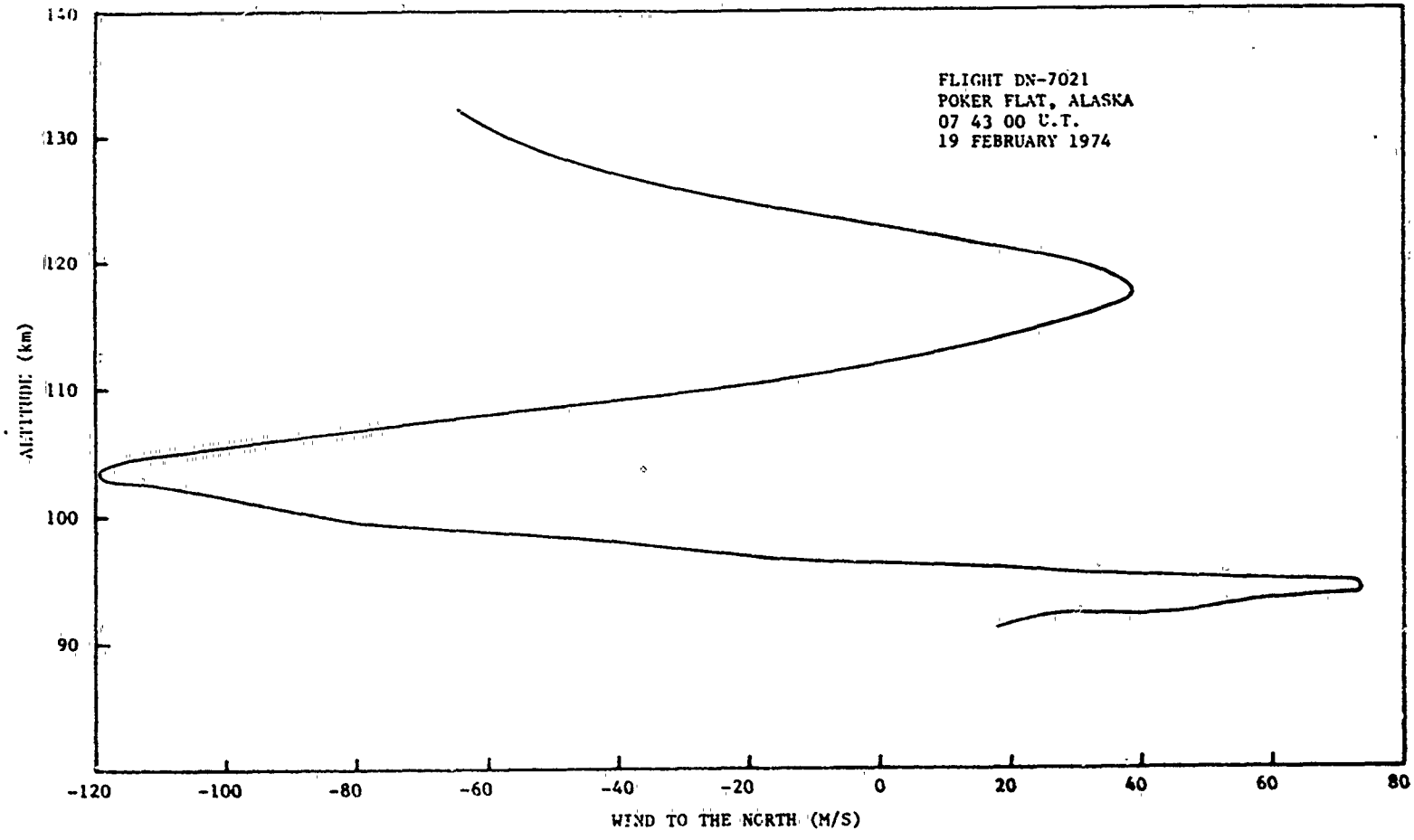

Figure 2. Northward component of winds for flight DN-7021.

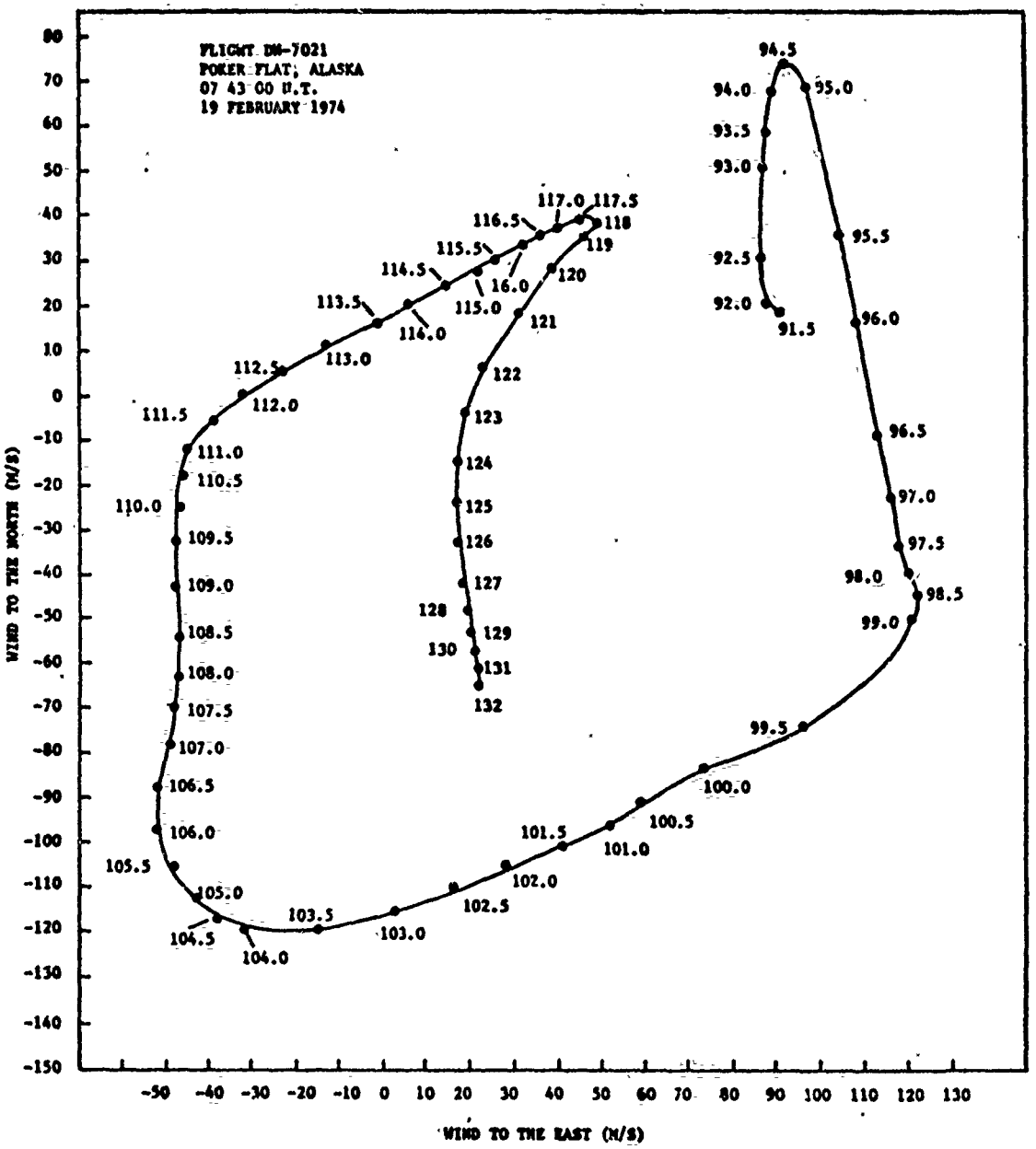

Figure 3. Hodograph of winds for flight DN-7021.

SECTION V

ANALYSIS OF VAPOR TRAIL DATA FROM FLIGHT A10.216-3

The vapor trail data of 27 March 1973 (Flight A10.216-3) presented two unique problems:

1. The vapor trail was photographed successfully from one observing site only (Ester Dome).
2. The rocket trajectory data supplied by AFCRL for Flight A10.216-3 are unreliable for that portion of the rocket flight during which TMA was released. In particular, the recorded azimuth of the rocket varies erratically during this portion of the flight.

The first problem mentioned (single-site observations) can be overcome by the use of several sequential (in time) photographs of the trail. This procedure, however, necessitates knowledge of the rocket trajectory, which is required in order to fix a distance scale. The erratic record of the rocket trajectory over the portion of interest introduced a further serious complication.

To overcome these problems, the following procedure was utilized. At the outset, it was assumed that the range versus time information in the trajectory data was correctly recorded. A special graphical representation of the sequential trail photographs was used in conjunction with the reliable trajectory data to infer the most likely rocket trajectory. This trajectory information was in turn utilized to obtain wind values from the photographic trail data. The results are given in tabular form in Table 3. Figure 4 gives the altitude profile of the eastward wind, and Figure 5 gives the altitude profile of the northward wind. Figure 6 presents the winds in the form of a hodograph. Numbers adjacent to points on the hodograph indicate the altitude.

The uncertainty in the results arising from the uncertainty in the trajectory data can be specified in terms of a corresponding uncertainty in altitude. There is an absolute uncertainty of 1 kilometer in altitude. The relative uncertainty is approximately 1/2 kilometer below the altitude of 110 kilometers, approximately 1 kilometer between 110 and 135 kilometers, and approximately 2 kilometers at the upper altitude range (145 to 160 kilometers).

TABLE 3

WIND COMPONENTS FOR FLIGHT A10.216-3. U IS EASTWARD COMPONENT, V IS NORTHWARD COMPONENT

H (km)	U (m/s)	V (m/s)	H (km)	U (m/s)	V (m/s)
91.4	3	0	113.5	-74	63
92.0	16	-9	114.5	-78	85
93.0	28	-20	115.0	-80	92
94.0	34	-31	116.0	-88	107
95.0	34	-38	117.0	-91	116
96.0	25	-39	118.0	-89	128
97.0	8	-30	119.0	-84	138
97.5	-7	-20	119.5	-72	150
98.0	-13	-14	120.0	-54	164
98.5	-18	-7	120.5	-38	177
100.0	-22	4	121.5	-29	181
101.3	-24	7	123.0	-27	179
102.5	-26	5	125.0	-29	150
103.5	-33	6	126.0	-30	140
105.0	-48	12	127.0	-29	128
106.0	-32	7	129.0	-20	111
106.5	-25	2	131.0	-7	92
107.0	-17	-8	134.0	3	74
107.5	-13	-20	136.0	0	64
108.0	-15	-30	138.0	-6	55
108.5	-34	-39	140.0	-18	47
108.8	-43	-41	143.0	-36	38
109.0	-54	-36	145.0	-56	32
109.5	-56	-19	147.0	-74	28
111.0	-54	0	150.0	-98	27
112.0	-55	10	157.5	-117	32
113.0	-60	27	155.0	-133	40
113.2	-68	42	157.5	-148	50
			160.0	-161	54

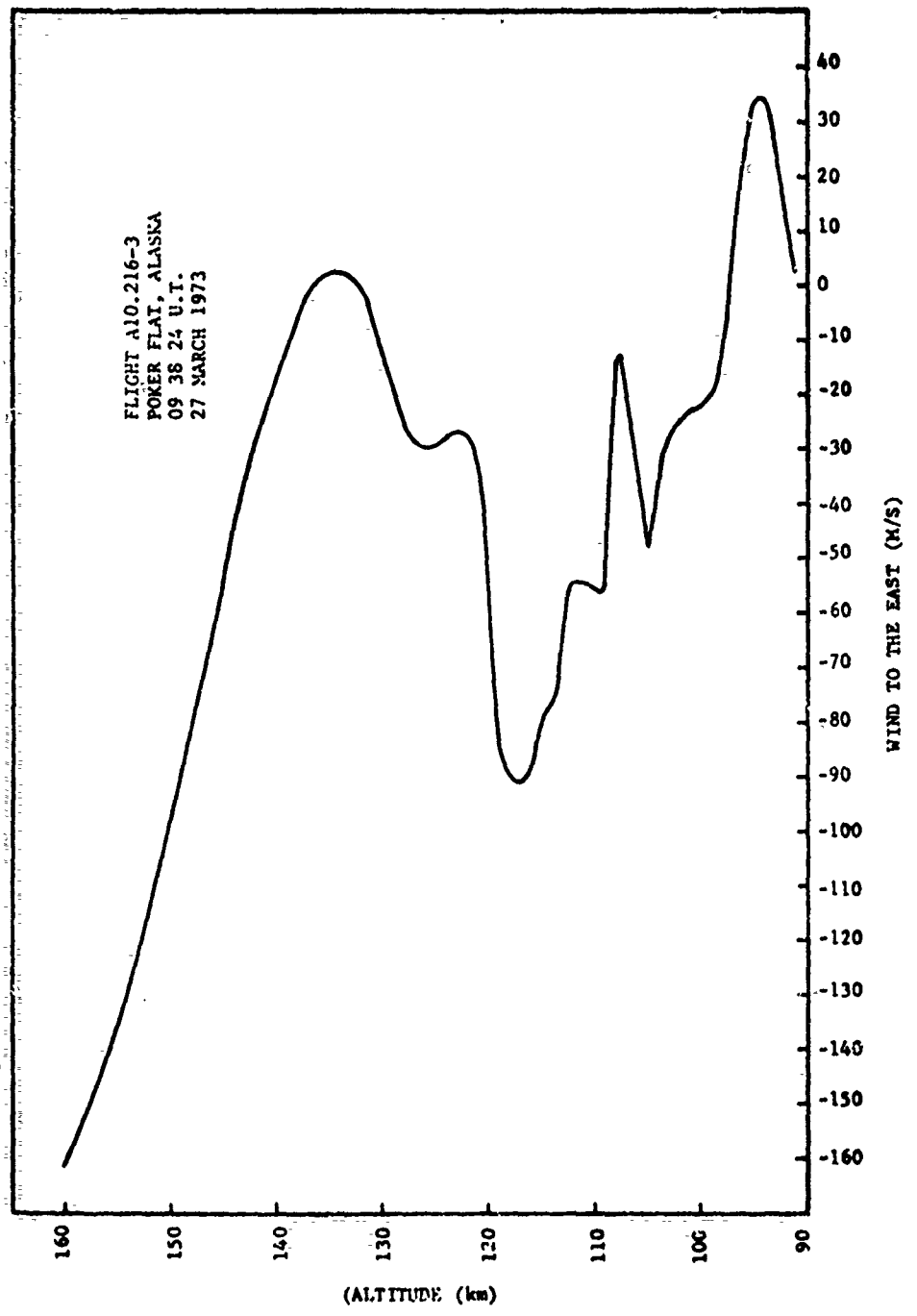

Figure 4. Eastward component of winds for flight A10.216-3.

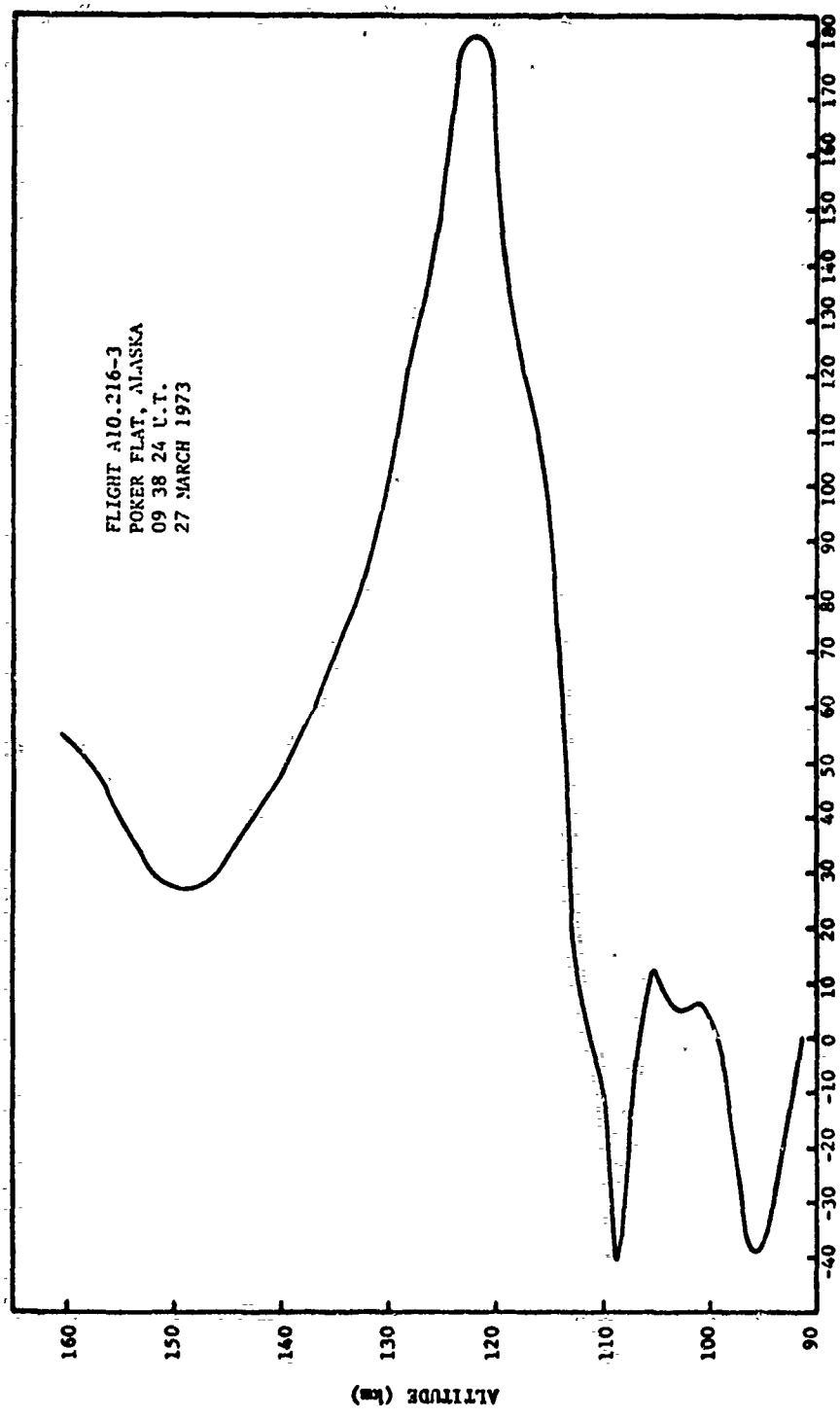

Figure 5. Northward component of winds for flight A10.216-3.

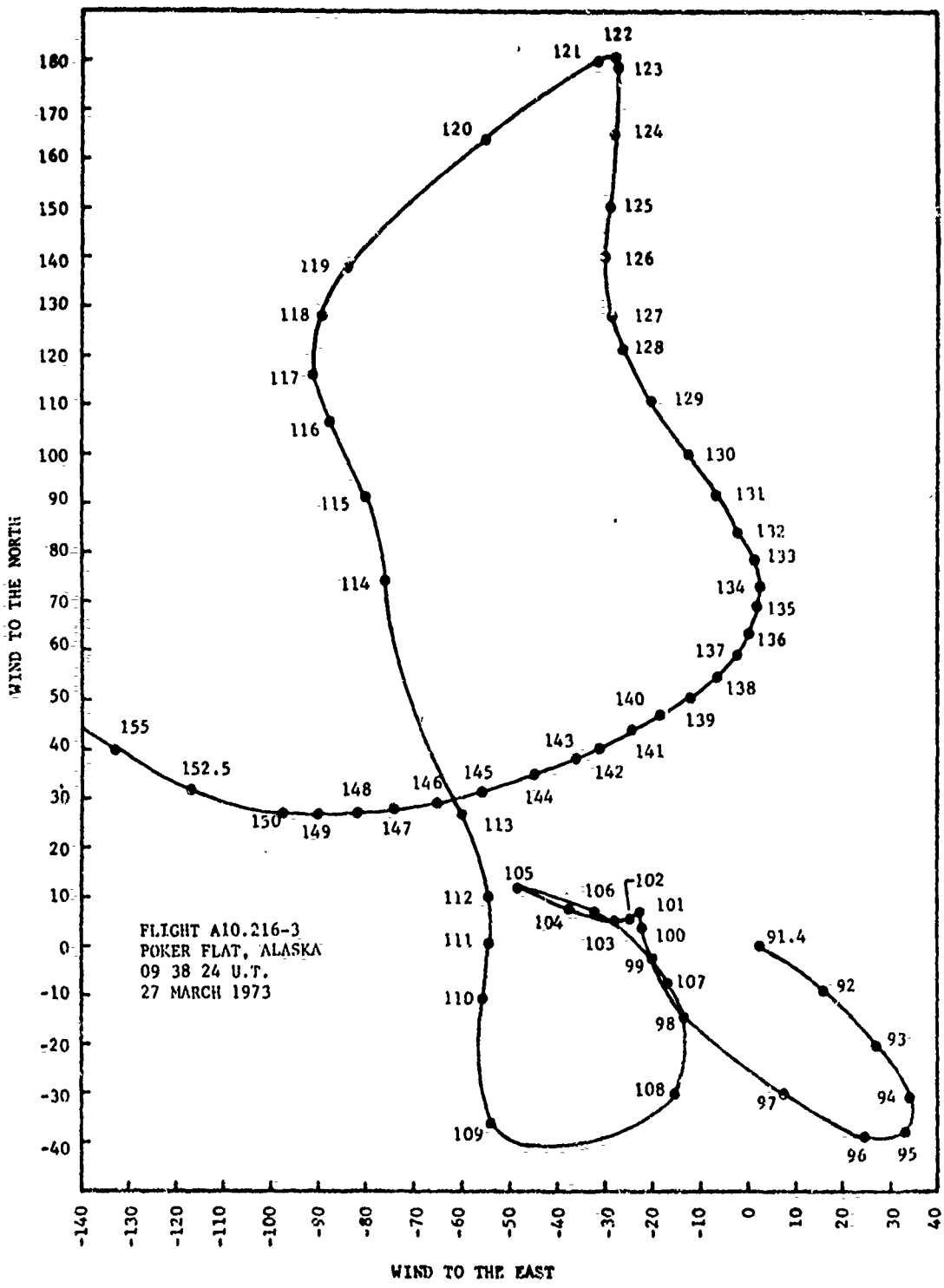

Figure 6. Hodograph of winds for flight A10.216-3.

SECTION VI

CONCLUSIONS AND RECOMMENDATION

Comparison of the data from Flights A10.216-3 and DN-7021 shows that the wind profiles are very different at the two times. The differences are easily observed by comparing the location of the origin in the hodographs. The same conclusion is reached when data from previous measurements at Poker Flat and from Fort Churchill, Canada, are considered. It must be concluded that the thermospheric dynamics at northern latitudes are not predictable at the present time and must be directly observed. However, the single site triangulation procedure allows relaxation of the previously severe weather restrictions which reduces the difficulties associated with coordinated measurements. The use of a high flying jet aircraft completely eliminates the weather dependence and allows measurements during the daytime as well. A series of measurements which allow detailed comparison with the results obtained with the incoherent scatter radar at Chatanika are particularly recommended in order to verify the neutral motions deduced from those observations and to aid in the development of that systems large potential for monitoring of atmospheric parameters.